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Report on Freshwater Planaria from Borneo

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Dr. M. HIRANO of Yoshida College, Kyoto University, a member of "The Kyoto University Borneo Expedition, 1963-1964", entrusted the author with his collection of freshwater planaria of Borneo. The material from this area, of which freshwater planarians have not hitherto been explored, was gladly received.

Only two specimens fixed on the field in 3 percent formalin were available for this study (KAWAKATSU's Specimen Lot No. 414 group). According to Dr. HIRANO, the worms were found in a shallow brooklet (altitude, 1000 m; about 1 m wide; slowly running and very clean water; bottom pebbles), source of the Sungai Jaglang (also spelled Jalan; a tributary of the Sungai Anap), located at the foot of Mt. Kana (south-west of Bintulu faced on the South China Sea), Sarawak-IV, Borneo. They were collected and fixed on November 22, 1963. After examination of the preserved specimens under a binocular microscope, it was found that one of the two specimens examined is in a sexually mature state. Unfortunately, no photographs of the preserved specimens were prepared because the sexual specimen was rather twisted along the antero-posterior body axis. I have made a series of sections of them (stained with Delafield's haematoxylin and eosin; No. 414 a and b). This Bornean triclad belongs to an undescribed species of the genus *Dugesia* of the family Planariidae, the description of which will be given below and it is new to turbellariology.

The author is indebted to Dr. Minoru HIRANO, Professor of Botany of Yoshida College, Kyoto University, who kindly handed to him this valuable material. He is also indebted to Dr. Riôzô YOSHII, Professor of Zoology of the same college, as well as Dr. HIRANO, who kindly permitted the chance of this publication to the present author in their Contributions from the Biological Laboratory, Kyoto University. Dr. Gentaryô IMADATÉ, of the Biological Laboratory of Kônodai College, Tokyo Medical and Dental University, who went to North Borneo in 1968, was kind enough to make an effort to collect additional specimens of Bornean freshwater planarians by a request from the author. Although this attempt ended without definite result during his expedition, but the author wishes to express his thanks for Dr. IMADATÉ's deep interest.

Order TRICLADIDA

Suborder PALUDICOLA or PROBURSALIA

Family PLANARIIDAE

Genus *Dugesia* GIRARD, 1850

Dugesia borneana KAWAKATSU spec. nov. Figs. 1 (A, B and C) and 2; Pl. 1 (Figs. A, B and C)

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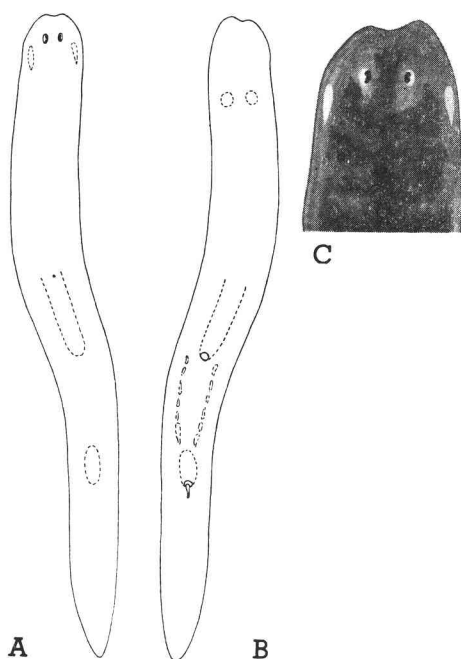


Fig. 1. *Dugesia borneana* KAWAKATSU spec. nov.
A and B: sketches of the preserved specimen (No. 414 a). Actual length, 17 mm.
A: dorsal view. B: ventral view. Notice a pair of ovaries and the spermiducal vesicles.
C: enlarged painting of the head of the same specimen.

Description. This is a middle-sized, slender and pigmented epigeic species. The appearance of the sexually mature specimen in the preserved condition is shown in Figure 1 (A, B and C). This specimen is 17 mm in body length and about 2 mm in width. The head is a low triangular form (the anterior tip of the head is bent upwards in my specimens examined) with blunt auricles; no distinct narrowing ("neck") occurs behind the head. The elongated body remains about the same width to the posterior level of the copulatory apparatus and finally terminates in the pointed posterior end.

According to the observation made by Dr. HIRANO in the spot, the general color of the living worms is a uniform dark brown. In the preserved specimen the margin of the body and the areas above the pharynx and the copulatory organs are lighter brownish color. The ventral surface is a light brownish gray.

The two eyes are situated on the dorsal side of the head; the distance between them is somewhat wider than one-third the width of the head at the level of eyes. A white colorless area is conspicuous around each eye (Fig. 1 A and C). The non-pigmented auricular sense organ which is an elongated willow-leaf shape is visible on both sides of the head.

The pharynx is inserted a little ahead of the middle of the body and measures in length about one-seventh of the body length. The mouth is situated about the halfway of the body. In histological structure the pharynx is typical of the family Planariidae; the inner musculature of the pharynx consists of two distinct layers, a thick circular layer adjacent to the epithelium of the pharynx lumen and a thinner layer of longitudinal fibres. The anterior intestinal trunk bears 18 to 20 branches on each side; each posterior trunk has 20 or more short lateral branches.

In the preserved sexually mature specimen, a pair of large ovaries is recognizable from the ventral side. A pair of well-developed spermiducal vesicles and the parts of the copulatory apparatus are also seen in my specimen as white, opaque organs. The genital pore is situated somewhat frontal level of the middle of the postpharyngeal region (Fig. 1 B). In my specimen illustrated in Figure 1 (B), a short tubular

process protruded from the genital pore was seen when the material was examined under a binocular microscope. In histological sections it was proved that this process is a coagulated secretion from the penis glands.

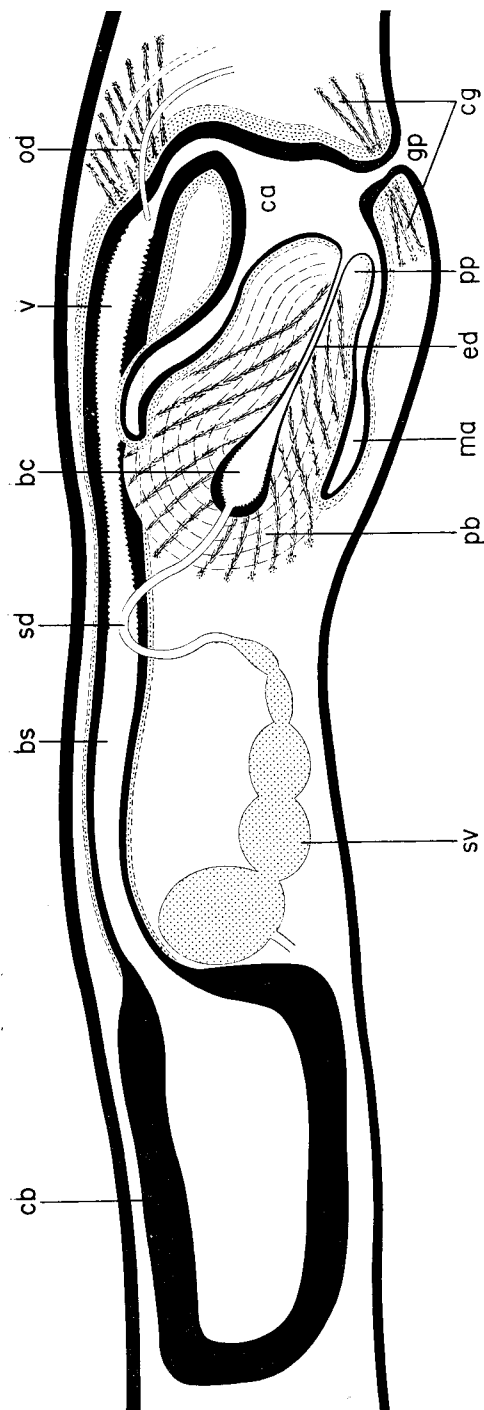
The dorsal epithelium is much thicker than the ventral and heavily provided with rhabdites. The marginal adhesive zone is slightly developed.

In my slides the large specimen (No. 414 a: sagittal sections) was proved to be in a fully sexually mature state. The other small specimen (No. 414 b: transverse sections) was also sexual but not in a fully mature state (i. e., a number of non-mature testes and a part of young penis were seen in the slides). A pair of large ovaries occurs in the ventral side between the fifth and the sixth intestinal diverticula. The two ovovitelline ducts converge at the posterior level of the copulatory apparatus and then bend upwards and open separately into the posterior part of the bursal canal (or the terminal part of the vagina) (Fig. 2). Numerous yolk glands (or vitellaria) are distributed throughout the body in the surrounding parenchyme.

The testes are numerous, of small size, and are situated dorsally. In my sagittal sections of the sexual specimen, they are arranged on either side of the middle line in one to two longitudinal zones extending from the posterior level of the ovaries to the nearly posterior end of the body. In this species the sperm ducts form the highly developed spermiducal vesicles packed with sperm on either side of the postpharyngeal region between the mouth and the anterior level of the penis bulb. On the side of the penis bulb, each narrows to a slender duct that ascends vertically through the penis bulb as shown in Figure 2, then curves postero-ventrally, and opens into the bulbar cavity separately.

Figure 2 shows a sagittal view of the copulatory apparatus of Mt. Kana specimen. Photomicrographs of the parts of the copulatory apparatus of the same specimen (holotype) are also shown in Plate 1 (Figs. A, B and C). The genital pore leads immediately into a wide cavity which represents as the common genital antrum. It continues into a narrow terminal part of the bursal canal postero-dorsally and into the male genital antrum anteriorly. The wall of both the common and male genital antrums is clothed with a tall, glandular epithelium, below which occur two layers of muscles, the outer circular fibres and the inner longitudinal ones. The epithelial cells of the wall of the common antrum are insunk type and are much taller than those of the male antrum (Fig. 2).

The penis has a considerably large, hemispherical bulb embedded in the parenchyme and a very large papilla of a cylindrical shape projecting into the male genital antrum (Fig. 2 and Pl. 1, Fig. A). Both the bulb and the papilla are strongly muscular. The bulb contains a moderately wide, pestle-shaped cavity with a smooth outline, the bulbar cavity or the seminal vesicle. It continues to the papilla as a narrow ejaculatory duct without any diaphragm and opens at its tip (Fig. 2). Concerning the penial anatomy of this Bornean species, I have examined only one sexual specimen (its papilla may be a well-extended state of this organ). There is however scarcely any doubt that the penis papilla of the present new species is an asymmetrical shape.



Although the ejaculatory duct do not open at the ventral side of the papilla, as seen in many Oriental and Asiatic species of *Dugesia* with an asymmetric papilla, it is ventrally located in the papilla, not in its center. Both the bulbar cavity and the ejaculatory duct (i. e., penis lumen) are lined with the nucleated glandular epithelium. It was observed that the epithelial cells are well developed at the bulbar cavity. The bulb is pierced by numerous gland ducts (penis gland) containing eosinophilous granules which open into the entire course of the penis lumen.

In the specimen examined, there is no constriction at the basal part of the penis papilla (i. e., atrial fold; cf. BALL 1970). As it is illustrated in Figure 2, however, a slightly developed swelling is found at the upper side of the basal part of the papilla. This structure seems to be an early stage of differentiation of the constriction at the basal part of the papilla which is found in several Asiatic species of *Dugesia*. The outer wall of the papilla is covered with a tall, cubical epithelium similar to that which lines the genital antrum. This epithelium has insunk nuclei in almost all its parts. Below the epithelium there are two layers of muscle fibres, one circular and the other longitudinal.

Fig. 2. Diagram showing the sagittal view of the copulatory apparatus of *Dugesia borneana* KAWAKATSU spec. nov. No. 414 a. bc, bulbar cavity; bs, bursa stalk; cb, copulatory bursa; ca, common antrum; cg, cement gland; ed, ejaculatory duct; gp, genital pore; ma, male antrum; od, ovovitelline duct; pb, penis bulb; pp, penis papilla; sd, sperm duct; sv, spermiducal vesicle; v, vagina.

The copulatory bursa is very large in size and is somewhat irregularly lobed. It is lined with a tall glandular epithelium. The bursa stalk, a narrow and extraordinarily long duct of almost uniform diameter, runs posteriorly close to the middle line and then curves ventrally and opens into the common genital antrum. Below the nucleated epithelium, there are two layers of muscle fibres, one circular and the other longitudinal. The posterior half of the bursa stalk forms the thick walled cavity or the vagina. In this part the muscle fibres become thicker than in the anterior half of the bursa stalk. The epithelium of the distal part of the vagina has insunk nuclei similar to that of the common genital antrum. The wall of the vagina is pierced by the ducts of eosinophilic shell glands which open into the cavity. Two ovovitelline ducts accompanied by many eosinophilic glands at the region near the vagina. Weakly eosinophilous cement glands open into the common antrum near the genital pore.

Holotype. One set of sagittal serial sections of the Mt. Kana specimen (Specimen No. 414 a, 14 slides) preserved in KAWAKATSU's cabinet of Fuji Women's College in Sapporo; also one set of transverse sections (No. 414 b) of non-fully mature specimen.

Locality. A brooklet of the source of the Sungai Jalgang, Mt. Kana, Sarawak-IV, Borneo; collected by Dr. M. HIRANO on November 22, 1963.

Taxonomic Remarks and Differential Diagnosis. The known species of the genus *Dugesia* (sensu HYMAN 1939, 1951) including a number of uncertain or insufficiently described forms reported from the South-east Asia and the Far East were listed in my previous articles (cf. ICHIKAWA & KAWAKATSU 1964; KAWAKATSU 1969 a). After these articles were published, BALL (1970), who described two new *Dugesia* species from Ceylon and Batu Caves in Malaya, discussed the taxonomy of the Oriental and Japanese species of the genus. Recently, I have also studied the taxonomy of non-sexual specimens of *Dugesia* from South India (cf. KAWAKATSU & BASIL 1971) and *Dugesia japonica* from three new additional localities of the Ryûkyû Islands (cf. KAWAKATSU & TANAKA 1971). At present I am planning on writing a number of taxonomic papers about several species of *Dugesia* from the Asiatic countries and some of which were already examined in my slides. Therefore, I hope to make a limited taxonomic discussion in the present paper.

The valid *Dugesia* species of the Oriental region and Japan are as follows: *Dugesia bactriana* DE BEAUCHAMP, 1959, from Afghanistan and West Pakistan (cf. KAWAKATSU 1969 c); *Dugesia lindbergi* DE BEAUCHAMP, 1959, from Afghanistan and West Pakistan (cf. KAWAKATSU 1969 c); *Dugesia indica* KAWAKATSU, 1969, from India; *Dugesia nannophallus* BALL, 1970, from Ceylon; *Dugesia andamanensis* (KABURAKI), 1925, from the Andaman Islands; *Dugesia burmaensis* (KABURAKI), 1918, from Burma; *Dugesia annandalei* (KABURAKI), 1918, from Burma; *Dugesia batuensis* BALL, 1970, from Batu Caves in Malaya; *Dugesia hymanae* (ŠIVICKIS), 1928, from the Philippine Islands; *Dugesia japonica* ICHIKAWA et KAWAKATSU, 1964, from the Far East including the Japanese Islands; *Dugesia izuensis* KATÔ, 1943, from Central Japan.

Among these eleven species, *Dugesia andamanensis* and *Dugesia hymanae* were described insufficiently. According to my recent observations, the latter form is a good

species. In my slides of the Cébu specimens which I have identified as *Dugesia hymanae* (syn. *Planaria hymani* ŠIVICKIS, 1928) has a large penis bulb and a middle sized, slender, but slightly asymmetrical penis papilla with a well-developed constriction at its basal part. The very wide bulbar cavity continues to the ejaculatory duct with a distinct diaphragm in its course (this character was overlooked in the ŠIVICKIS' original description of *Planaria hymani*; cf. Pl. LI, Figs. 5 and 6). The copulatory bursa is not so large. The terminal part of the bursa stalk is not differentiated as the vagina in this species (KAWAKATSU's unpublished data).

From the result of the comparative anatomy of the copulatory apparatus of the known *Dugesia* species of the Oriental region and Japan, only one species, *Dugesia annandalei*, has a striking resemblance to the present new species from Borneo not only in the external appearance but also in the anatomy of the reproductive system. *Dugesia* (olim *Planaria*) *annandalei*, the species described by a single specimen which was collected from a muddy bottom of Inlé Lake, Southern Shan States in Burma, is a small and pigmented species. Its penis has a hemispherical bulb and an elongated conical papilla of symmetrical shape. The bulbar cavity continues to an ejaculatory duct without any diaphragm in its course. The copulatory bursa is middle sized. Judging from the original description and the figure of the copulatory apparatus, the vagina is less-developed in this species (cf. KABURAKI 1918, pp. 191-193, Pl. XXVII, Figs. 2, 6 and 7). *Dugesia borneana*, the present new species, can be distinguished from *Dugesia annandalei* by the external features and the details of the anatomy of the copulatory apparatus, such as: of elongated body form, of possessing a slightly asymmetrical penis papilla, of very large copulatory bursa with a long bursa stalk and of a presence of a well-developed vagina.

There are some problems concerning the taxonomy of *Dugesia annandalei*. Up to the present, a total of seven species of *Dugesia* were recorded from the Notogaea (Australia and New Zealand) (cf. KAWAKATSU 1969 b, p. 8, foot-note 6; see also BALL & FERNANDO 1969). Histologically and morphologically *Dugesia annandalei* is somewhat similar to two Notogaean species, *Dugesia glandulosa* (KENK), 1930 (olim *Planaria striata* WEISS, 1910) and *Dugesia schauinslandi* (NEPPI), 1904 (syn. *Spathula limicola* NURSE, 1950). In fact DE BEAUCHAMP (1939, p. 74, 1940, 1951, pp. 94-96) expressed his opinion that *Dugesia annandalei* may reduce to a synonym of *Dugesia glandulosa*; MARCUS (1953, p. 20) agreed with this opinion. It is true that the figure of the copulatory apparatus of *Dugesia glandulosa* (cf. WEISS 1910, Taf. XX, Fig. 25) is closely similar to that of *Dugesia annandalei* (cf. KABURAKI 1918, Pl. XVII, Fig. 6). However, the penis bulb of the former species is very small or less-developed. In my opinion, the South-east Asiatic and Australian forms may be two different species from each other. Geographically, the present new species, *Dugesia borneana*, is located at the middle of the distributional range of the above-mentioned two species. *Dugesia borneana* can be easily separated from *Dugesia glandulosa* as well as *Dugesia schauinslandi* by the details of the penial anatomy.

The present new species differs from the other members of the genus in the

following characters: preseed animal elongated, narrowed posteriorly, to 17 mm, colored uniform dark brown above, lighter below; head low triangular with blunt auricles; two eyes; numerous dorsal testes lie in one to two rows on either side and extend to the nearly posterior end; penis bulb large, hemispherical in shape and strongly muscular with a moderately wide pestle-shaped bulbar cavity into which sperm ducts enter separately; slightly asymmetrical penis papilla large and cylindrical form without diaphragm in the ejaculatory duct which is ventrally located in the papilla; without constriction at the basal part of the papilla; copulatory bursa very large, with a narrow and extraordinarily long bursal canal which opens into the common genital antrum; the posterior half of the bursa stalk forms a well-developed vagina into which ovovitelline ducts enter separately.

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Note Addid in Proof. Since this paper was submitted for publication the following papers dealing with the taxonomy and chorology of the Asiatic *Dugesia* species have been prepared. Dr. A. DAMM also made a short mention of an unpublished study on freshwater triclad populations from India by Mr. M. CHAUDHURY.

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Explanation of Plate 1

- A, B and C. Photomicrographs showing the sagittal view of the copulatory apparatus of *Dugesia borneana* KAWAKATSU spec. nov.
- A. Copulatory apparatus (posterior part). No. 414 a. bc, bulbar cavity ; ca, common antrum ; ed, ejaculatory duct ; gp, genital pore ; ma, male antrum ; pb, penis bulb ; pp, penis papilla ; v, vagina.
- B. Copulatory apparatus (anterior part). No. 414 a. bs, bursa stalk ; cb, copulatory bursa ; sv, spermiducal vesicle.
- C. Enlarged photomicrograph of the part of the wall of the vagina. No. 414 a. Top of the photograph is the bursal canal. Notice the glandular epithelium and the muscle fibres of the vagina.

